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## Original Study

# Risk Factors, Presentation, and Course of Coronavirus Disease 2019 in a Large, Academic Long-Term Care Facility



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## A B S T R A C T

**Keywords:**  
COVID-19  
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**Objective:** To describe clinical characteristics and risk factors associated with coronavirus disease 2019 (COVID-19) in long-stay nursing home residents.

**Design and Participants:** Retrospective cohort study (March 16, 2020 to May 8, 2020).

**Setting:** Academic long-term chronic care facility (Boston, MA).

**Participants:** Long-term care residents.

**Methods:** Patient characteristics and clinical symptoms were obtained via electronic medical records and Minimum Data Set. Staff residence was inferred by zip codes. COVID-19 infection was confirmed by polymerase chain reaction testing using nasopharyngeal swabs. Residents were followed until discharge from facility, death, or up to 21 days. Risks of COVID-19 infection were modeled by generalized estimating equation to estimate the relative risk (RR) and 95% confidence intervals (CI) of patient characteristics and staff community of residence.

**Results:** Overall 146 of 389 (37.5%) long-stay residents tested positive for COVID-19. At the time of positive test, 66 of 146 (45.5%) residents were asymptomatic. In the subsequent illness course, the most common symptom was anorexia (70.8%), followed by delirium (57.6%). During follow-up, 44 (30.1%) of residents with COVID-19 died. Mortality increased with frailty (16.7% in pre-frail, 22.2% in moderately frail, and 50.0% in frail;  $P < .001$ ). The proportion of residents infected with COVID-19 varied across the long-term care units (range: 0%–90.5%). In adjusted models, male sex (RR 1.80, 95% CI 1.07, 3.05), bowel incontinence (RR 1.97, 95% CI 1.10, 3.52), and staff residence remained significant predictors of COVID-19. For every 10% increase in the proportion of staff living in a high prevalence community, the risk of testing positive increased by 6% (95% CI 1.04, 1.08).

**Conclusions and Implications:** Among long-term care residents diagnosed with COVID-19, nearly one-half were asymptomatic at the time of diagnosis. Predictors of COVID-19 infection included male sex, bowel incontinence, and staff residence in a community with a high burden of COVID-19. Universal testing of patients and staff in communities with high COVID-19 rates is essential to mitigate outbreaks.

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The coronavirus disease 2019 (COVID-19) pandemic caused by a novel coronavirus (severe acute respiratory syndrome coronavirus 2, SARS-Cov-2) has had a marked impact on every sector of society, with long-term care facilities and nursing homes bearing a disproportionate amount of disease burden and mortality.<sup>1,2</sup> In 2019 1.4 million persons,

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or approximately 3% of the US population age 65 years or older, resided in long-term care facilities. Presently in the United States, 40% of all COVID-19 related deaths have occurred among nursing home residents,<sup>3</sup> with at least 6 states reporting more than one-half of deaths are in these facilities.<sup>4</sup> The World Health Organization reported a similar proportion of fatalities in Europe from long-term care facilities.<sup>5</sup> Thus understanding the presenting clinical symptoms, clinical course, and predictors of COVID-19 within long-term care facilities is paramount to crafting an informed societal response to this pandemic.

Limited information exists on the presenting characteristics and clinical course of COVID-19 in long-term care residents.<sup>6</sup>

Epidemiologic studies suggest that many persons infected with COVID-19 do not develop symptoms: among 200 randomly selected community dwellers, 30% had evidence of antibodies to COVID-19 despite reporting no symptoms.<sup>7</sup> Aging can affect common disease presentations, and older adults often present with atypical symptoms. Additional challenges are posed when long-term care residents with advanced dementia have an impaired ability to communicate their symptoms. A better understanding of the presenting symptoms and clinical course of COVID-19 in this vulnerable population may hasten diagnosis, which is critical to prevent the rapid, unintended spread of disease in this setting.

Factors related to transmission of COVID-19 within long-term care facilities are also not well understood. Media attention has suggested that COVID-19 transmission in nursing homes may be related to poor quality of care,<sup>8</sup> but patient and staff characteristics are likely to affect disease burden. For example, behavioral symptoms of dementia, such as wandering, could increase the risk of transmission. Also, residents with advanced dementia typically require assistance with toileting and feeding, demanding close personal contact with direct care staff. Staff who live in a neighborhood more severely affected by COVID-19 may then inadvertently increase the risk of transmission among these residents.

The objective of this study was to describe the presenting clinical characteristics and outcomes of long-term care residents affected by COVID-19 in a large, academic long-term care facility. Further, we described variation in the prevalence of COVID-19 infection across units, and we identified patient and staff characteristics associated with COVID-19 infection. We hypothesized that patient characteristics, such as wandering, and staff residence (ie, living in a community with a high burden of COVID-19), would be associated with testing positive for COVID-19.

## Methods

### Study Population

This study was conducted in an approximately 500-bed academic long-term care facility in the Boston area. During the study period, there were 8 long-term care units, licensed as a long-term chronic care hospital. In addition, the facility housed 1 medically complex acute care unit, and a subacute rehabilitation unit which are excluded from this study. A no-visitor policy took place on March 12, 2020, with screening of staff symptoms upon facility entry. Staff were instructed to wear masks beginning March 25, 2020. This study was approved by the Institutional Review Board at Hebrew SeniorLife. Neither patients nor the public were involved in the design, or conduct, or reporting, or dissemination plans of our research.

All consecutive patients in the facility tested for COVID-19 between March 16, 2020 and May 8, 2020 were included in the study. Between March 16, 2020 and April 10, 2020 COVID-19 tests were ordered based on clinical suspicion of the disease or exposure to a confirmed case. Between April 11, 2020 and April 17, 2020, universal testing was implemented and every resident in the facility was tested for COVID-19. Patients who tested negative were re-tested based on clinical suspicion of the disease or known exposure to confirmed cases. We excluded residents with a positive COVID-19 test prior to admission to the facility ( $n = 16$ ), patients on the subacute rehabilitation unit ( $n = 32$ ), and patients in the medically complex acute care unit ( $n = 17$ ).

### COVID-19 Testing

Data on the name, dates, and test results of patients receiving the polymerase chain reaction test for COVID-19 was prospectively collected in a facility log. Testing was obtained by clinical staff within

the facility using nasopharyngeal swabs and processed at an affiliated hospital with most results available within 24 hours.

### Clinical Presentation

Using the electronic medical records of the facility, we reviewed nursing, nutrition, and medical provider notes to identify clinical symptoms on the calendar day the first positive test was ordered and the 3 preceding days, including of cough, anorexia, vomiting, or diarrhea. Delirium, either documented by a geriatrician or reported as an acute change in mental status or lethargy, was noted. Fever, defined as any recorded temperature of greater than or equal to 100°F, was documented from the vital sign reports.

We obtained information on clinical symptoms and outcomes following a positive test, including vomiting, diarrhea, delirium, and anorexia. The total number of calendar days with fever, the need for supplemental oxygen, hospitalization, and falls (during the 3 days before testing or any time during follow-up) were recorded. Symptoms were evaluated until death, or until 21 calendar days following the first positive test or end of study follow-up (May 8, 2020).

### Resident Characteristics

We collected information on resident characteristics including demographics such as age, sex, and race using the MDS assessment between December 2019 and February 2020. The MDS is a federally mandated clinical assessment completed on all nursing home residents at the time of admission and quarterly thereafter.<sup>9</sup> Information on clinical characteristics including cognitive function, as measured by the validated Cognitive Performance Scale,<sup>10</sup> functional characteristics, body mass index, and behavioral symptoms, were also obtained. A frailty index (range 0–1, 1 indicates more severe frailty) was calculated using 35 items from the MDS, using a standard deficit accumulation approach.<sup>11</sup> Variables used in construction of the frailty index include comorbidities, functional activities of daily living, sensory impairment, weight loss, and cognition.

### Staff Community of Residence

Staff typically provide care on a single unit and rarely float between units. We obtained a list of the home zip codes for all nurses and personal care assistants. Zip codes were used to determine the rate of COVID-19 infection in each staff member's community of residence. Rates of infection were obtained from publicly available websites through May 7, 2020.<sup>12–14</sup> A community was considered to have a high infection rate if the rate was in the top decile of COVID-19 rates for the state of Massachusetts ( $\geq 1277$  cases/100,000 persons). Staff members represent a total of 368 persons with 91 distinct zip codes. The aggregated distribution and range of COVID-19 cases in the state and community where staff members live is listed in [Supplementary Table 1](#).

### Statistical Analysis

We described resident characteristics overall, and according to COVID-19 testing results, comparing with  $\chi^2$  or  $t$ -tests for categorical and continuous variables, respectively. Among patients who tested positive, we described clinical characteristics at presentation and clinical outcomes, including all-cause mortality. The clinical characteristic results were stratified by frailty status, categorized by calculated frailty index<sup>11</sup>: Pre-frail ( $<0.25$ ), mildly frail (0.25–0.34), or moderate-severely frail ( $\geq 0.35$ ). A statistical comparison of clinical characteristics as categorical variables was done using a  $\chi^2$  test. In a sensitivity analysis, we excluded residents who were diagnosed near

the end of the study period and without the opportunity for 21 days of follow-up.

The proportion of residents testing positive for COVID-19 virus was calculated on each of the 8, long-term care units. Demographic and clinical characteristics of all patients on each unit were aggregated, regardless of COVID-19 status. We classified units as having a high burden of COVID-19 disease if >50% of residents were affected, a moderate burden if 5%–50% of residents were affected, and a low burden if <5% of residents were affected by disease. Comparison of resident characteristics and staff residence by unit were done using a 1-way analysis of variance. As a sensitivity analysis, we repeated our analyses including only those who died or had 21 days of follow-up (Supplementary Table 2).

Finally, we developed a regression model of COVID-19 infection using the modified Poisson concept,<sup>15</sup> with estimation of relative risks and associated 95% confidence intervals by generalized estimating equations using a log link function. Both patient characteristics and aggregated staff residence data were used to model outcome of a positive COVID-19 test. Characteristics were entered into bivariate models, and those that were significant at the  $P \leq .10$  level were entered into the final model. Analyses were performed using Stata v 16.0 (StataCorp LLC, College Station, TX) and SAS v 9.4 (SAS Institute Inc, Cary, NC).

## Results

During the study period, 389 residents received 620 tests for COVID-19 (mean 1.6, range 1–6 tests). The mean (standard deviation) age of the study population was 86.8 (9.0) years; 253 (65.7%) residents were female; and 37 (9.6%) identified as having non-white race. One hundred forty-six residents (37.5%) had 1 or more positive tests for COVID-19. Characteristics of residents are listed in Table 1, according to COVID-19 test results. Residents who tested positive for COVID-19 were younger (85.0 years vs 87.9 years) and more likely to be male and nonwhite. Residents who tested positive for COVID-19 were also more likely to have severe cognitive and functional impairment, and behavioral symptoms, compared with residents who tested negative for disease.

At the time of the positive test, 35 (24.1%) of residents had cough, 31 (21.4%) residents had a fever, 26 (17.9%) residents had vomiting, 9 (6.2%) residents had diarrhea, and 26 (17.9%) had anorexia (Table 2). Other symptoms that were reported in less than 5% of residents included red eyes, abdominal pain, sore throat, tachycardia, shortness of breath, or unsteady gait. Delirium was documented in 18.6% of residents at the time of the positive test. Sixty-six residents (45.5%) were asymptomatic at the time of the positive test. Clinical symptoms at the time of presentation were similar according to frailty status with the exception that fever was more common in residents with mild (28.9%) or moderate to severe frailty (26.9%) as opposed to prefrail residents (4.9%,  $P = .01$ ).

The most common clinical symptoms reported during follow-up were anorexia (71.0%) and delirium (57.9%). Fifty-eight residents (40.0%) developed an oxygen requirement, and 22 residents (15.1%) experienced a fall during the 3 days before diagnosis or during follow-up. The mean number of days of fever was 1.8 (range 0–9). Nine residents (6.5%) were hospitalized. Twenty-one (15.0%) residents remained asymptomatic during follow-up, and an additional 8.8% residents had no symptom except anorexia during follow-up. During a median follow-up time of 21 days, 44 (30.1%) of residents with COVID-19 disease died. The proportion of residents who died from COVID-19 increased as frailty severity increased (16.7% in prefrail, 22.2% in moderately frail, and 50.0% in frail;  $P < .001$ ). Results were similar when we restricted our analysis to residents with the opportunity for 21 days of follow-up (Supplementary Table 2).

**Table 1**  
Characteristics of Long-Term Care Residents According to COVID-19 Diagnosis\*

Characteristics	Overall (n = 389)	COVID-19+ (n = 146)	COVID-19– (n = 243)	P Value
Age, y	86.8 ± 9.0	85.0 ± 9.3	87.9 ± 8.7	.001
Female	253 (65.7)	80 (55.9)	173 (71.5)	.002
Race				
White	348 (90.4)	118 (82.5)	230 (95.0)	<.001
Black	24 (6.2)	17 (11.9)	7 (2.9)	
Hispanic	10 (2.6)	5 (3.5)	5 (2.1)	
Other	3 (0.8)	3 (2.1)	0 (0)	
Body mass index	26.6 ± 5.9	25.6 ± 5.4	27.2 ± 6.1	.01
Cognitive Impairment <sup>†</sup>				
None or mild	113 (31.0)	46 (33.8)	67 (29.3)	.50
Moderate	189 (51.8)	65 (47.8)	124 (54.2)	
Severe	63 (17.3)	25 (18.4)	38 (16.6)	
Number of Independent ADLs				
0	147 (39.3)	36 (25.9)	111 (47.2)	<.001
1–2	124 (33.2)	59 (42.5)	65 (27.7)	
3–4	68 (18.2)	28 (20.1)	40 (17.0)	
5+	35 (9.4)	16 (11.5)	19 (8.1)	
Urinary continence <sup>‡</sup>	179 (48.6)	57 (41.3)	122 (53.0)	.06
Bowel continence <sup>‡</sup>	235 (63.3)	74 (54.0)	161 (68.8)	.02
Needs help eating	197 (52.8)	61 (43.9)	136 (58.1)	.008
Needs help with bed mobility	214 (57.4)	62 (44.6)	152 (65.0)	<.001
Needs help with mobility	288 (77.2)	91 (65.5)	197 (84.2)	<.001
Wandering	57 (15.3)	29 (20.9)	28 (11.9)	.05
Physical behaviors	53 (14.2)	24 (17.3)	29 (12.3)	.19
Verbal behaviors	93 (24.9)	34 (24.5)	59 (25.1)	.87
Diabetes	96 (25.7)	25 (18.0)	71 (30.2)	.008
CHF	59 (15.8)	12 (8.6)	47 (20.0)	.003
COPD	30 (8.0)	12 (8.6)	18 (7.7)	.75
Fall in prior quarter	70 (18.7)	25 (18.0)	45 (19.2)	.84
Frailty index (mean ± SD)	0.32 ± 0.10	0.30 ± 0.10	0.33 ± 0.09	.007

ADL, activities of daily living; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; MDS, Minimum Data Set; SD, standard deviation.

\*n = 16 missing MDS measures.

<sup>†</sup>Cognitive impairment defined by cognitive performance scale derived from MDS: 0–2 was mild, 3–4 was mod, 5 and 6 were severe.

<sup>‡</sup>Incontinence dichotomized frequently or always incontinent vs occasionally or never incontinent.

The proportion of residents infected with COVID-19 varied across the long-term care units (range: 0%–90.5%, Table 3) Units with a high burden of disease had more residents of younger age, severe cognitive impairment, and behavioral symptoms. Units with a high burden of disease were more likely to have staff members that lived in a community with a high rate of COVID-19 infection.

In unadjusted models, 8 resident characteristics were significant predictors of COVID-19 disease including younger age and wandering (Table 4). The proportion of staff living in a community with a high rate of COVID-19 was also a significant predictor of testing positive [relative risk (RR) 1.06, 95% confidence interval (CI) 1.05, 1.08]. In the adjusted model, 2 clinical characteristics were associated with an increased risk of testing positive for COVID-19: male sex (RR 1.80, 95% CI 1.07, 3.05) and bowel incontinence (RR 1.97, 95% CI 1.10, 3.52). Staff residence was a significant predictor of disease: for every 10% increase in the number of staff who live in a high prevalence community, the risk of testing positive for COVID-19 increased by 6% (95% CI 1.04, 1.08).

## Discussion

This retrospective cohort study of a large, long-term care facility underscores the devastating effect this virus may have in long-term care facilities and nursing homes. More than 40% of long-term care residents who were COVID-19 positive were asymptomatic at the time of testing and many never developed any symptoms. Among those presenting with symptoms, cough, fever, and delirium were most common, and 44 (30.1%) residents died. Across the long-term care units, there was considerable variation in the burden of infected

**Table 2**  
Clinical Symptoms and Outcomes of Nursing Home Residents With COVID-19 Infection

	Total (N = 146)	Prefrail FI* < 0.25 (n = 42)	Mild Frailty FI* 0.25–0.34 (n = 45)	Moderate to Severe Frailty FI* ≥ 0.35 (n = 52)	P Value
<b>Symptoms at the Time of Testing</b>					
Asymptomatic n (%)	66 (45.5)	23 (56.1)	17 (37.8)	22 (42.3)	.21
Fever n (%)	31 (21.4)	2 (4.9)	13 (28.9)	14 (26.9)	.01
Cough n (%)	35 (24.1)	7 (17.1)	16 (35.6)	11 (21.2)	.11
Delirium n (%)	27 (18.6)	7 (17.1)	7 (15.6)	13 (25.0)	.45
Anorexia n (%)	26 (17.9)	7 (17.1)	6 (13.3)	12 (23.1)	.45
Vomiting n (%)	13 (9.0)	3 (7.3)	7 (15.6)	3 (5.8)	.22
Diarrhea n (%)	9 (6.2)	3 (7.3)	3 (6.7)	3 (5.8)	.96
<b>Symptoms at Any Time</b>					
Days of fever (mean ± SD)	1.8 ± 2.0 (max 9)	1.6 ± 1.7	1.9 ± 2.1	1.8 ± 2.1	
Delirium n (%)	83 (57.6)	18 (43.9)	28 (62.2)	34 (66.7)	.07
Anorexia n (%)	102 (70.8)	28 (68.3)	35 (77.8)	35 (68.6)	.53
Fall n (%)	22 (15.1)	9 (21.4)	7 (15.6)	5 (9.6)	.28
Required oxygen n (%)	58 (40.0)	11 (26.8)	16 (35.6)	29 (55.8)	.13
Hospitalization n (%)	9 (6.5)	3 (7.9)	1 (2.3)	4 (8.0)	.45
Death n (%)	44 (30.1)	7 (16.7)	10 (22.2)	26 (50.0)	<.001

FI, frailty index; SD, standard deviation.

\*FI missing n = 7.

residents. Predictors of testing positive for COVID-19 included male sex, bowel incontinence, and a greater proportion of staff members living in a community with a high rate of COVID-19 infection.

Our results demonstrate that even in a frail, long-term care population, the prevalence of asymptomatic carriers of COVID-19 is substantial (45.5%). In a study of 89 nursing home residents in Washington State, 56% of residents who tested positive for COVID-19 were asymptomatic at diagnosis, but only 3 out of 27 residents (11.1%) remained asymptomatic 1 week after diagnosis using a prospective symptom survey.<sup>6</sup> We found a slightly greater proportion of residents remained asymptomatic over 3 weeks: 15.0% were asymptomatic and an additional 8.8% experienced only transient anorexia. Without universal testing, asymptomatic residents would go undiagnosed and may continue to spread the disease. It is challenging to prevent spread of the virus in long-term care given the high prevalence of moderate to severe cognitive impairment. Often, these patients are unable to adhere to infection control guidelines (eg, frequent handwashing, mask wearing), or safely isolate themselves. Ideally, residents with behavioral symptoms and COVID-19 should be managed in a designated unit.

Among symptomatic patients, delirium was one of the most common presenting clinical symptoms of COVID-19 infection. Atypical presentations of other infectious diseases, such as delirium with urinary tract infections, have been well described in frail, older adults and long-term care residents. Case reports of atypical presentations of COVID-19 include delirium as a presenting symptom,<sup>16–18</sup> and a high

prevalence of delirium has been reported among patients with COVID-19 in intensive care units.<sup>19</sup> A case-series of hospitalized patients from Wuhan, China with COVID-19 infection reported 7.5% experienced impaired consciousness or delirium.<sup>20</sup> In the Washington nursing home study, 25% of residents had altered mental status at the time of diagnosis.<sup>6</sup> Although we found a higher overall prevalence of delirium in our study (55.9% at any time during illness), we suspect delirium was underreported. We also found that falls were prevalent. Increased surveillance of delirium and falls in the nursing home using standardized tools may be beneficial to clinicians, administrators, and policy makers interested in the mitigating morbidity of COVID-19 within a facility.

Previous reports suggest that COVID-19 transmission in nursing homes may be associated with poor quality of care<sup>8</sup> or shortages of personal protective equipment. Our facility implemented the same infection control procedures across all long-term care units, yet we found that the prevalence of COVID-19 disease varied widely. Predictors of testing positive for COVID-19 included male sex and bowel incontinence. There have been a number of theories proposed for why men are more vulnerable, including androgen promotion of TPRSS2, a serine protease that promotes SARS-CoV2 penetration into host cells,<sup>21</sup> X-linked genetic differences,<sup>22</sup> or differences in the innate and adaptive immune function between men and women.<sup>22</sup> Direct care staff must have close, prolonged contact to assist patients with bowel incontinence, which may place these residents at greatest risk.

**Table 3**  
Unit Characteristics According to the Prevalence of COVID-19 Infection

	High Burden Units				Moderate Burden Units		Low Burden Units		ANOVA P Value
	Unit A	Unit B	Unit C	Unit D	Unit E	Unit F	Unit G	Unit H	
COVID-19 prevalence	38/42 (90.5)	33/44 (75.0)	36/52 (69.2)	29/56 (51.8)	5/29 (17.2)	4/44 (9.1)	1/60 (1.7)	0/62 (0.0)	<.001
<b>Patient Characteristics</b>									
Age (mean ± SD)	83.8 ± 7.6	82.6 ± 9.9	86.3 ± 9.7	87.0 ± 10.2	88.3 ± 7.4	82.6 ± 11.2	91.5 ± 5.1	90.0 ± 5.7	<.001
Male	55.0%	43.2%	37.3%	21.4%	42.9%	31.8%	28.8%	25.8%	.001
Severe cognitive impairment	43.6%	7.1%	14.6%	13.0%	20.0%	19.5%	12.3%	15.3%	<.001
No. of independent ADLs	1.47	2.47	1.58	1.67	2.19	1.40	1.47	1.33	.047
Bowel incontinence	66.7%	53.5%	44.4%	22.2%	22.2%	51.2%	19.3%	23.3%	<.001
Physical behaviors	48.7%	4.7%	6.0%	11.1%	7.4%	25.6%	3.5%	13.3%	<.001
Wandering	43.6%	9.3%	24.0%	5.6%	7.4%	27.9%	5.3%	5.0%	<.001
<b>Staff Residence</b>									
Proportion of staff members living in communities with high rates of COVID-19*(n/N, %)	29/37 (78.4)	30/38 (79.0)	43/49 (87.8)	44/54 (81.5)	30/35 (85.7)	52/58 (89.7)	17/49 (34.7)	19/48 (39.6)	<.001

ADL, activities of daily living; ANOVA, analysis of variance; SD, standard deviation.

\*High rate defined as ≥90th percentile for the state of Massachusetts (1277 cases/100,000 people), as reported by Massachusetts and Boston DPH as of May 6, 2020.

**Table 4**  
Resident and Staff Predictors of Incident COVID-19 Disease in a Large, Academic Nursing Home

	Unadjusted RR	95% CI	Adjusted RR*	95% CI
Age (per 5 y)	0.83	0.74, 0.93	0.99	0.97, 1.02
Male	1.90	1.24, 2.93	1.80	1.07, 3.05
Body mass index (per kg/m <sup>2</sup> )	0.95	0.92, 0.99	0.97	0.93, 1.02
Needs assistance with eating	0.56	0.37, 0.86	0.68	0.37, 1.24
Needs assistance moving in bed	0.43	0.28, 0.67	0.59	0.33, 1.06
Bowel incontinence	1.83	1.19, 2.82	1.97	1.10, 3.52
Needs assistance with locomotion	0.36	0.22, 0.58	0.55	0.29, 1.05
Wandering	2.02	1.14, 3.58	1.02	0.52, 1.98
Proportion of staff members living in communities with high rates of COVID-19 <sup>†</sup> (per 10% increase)	1.06	1.05, 1.08	1.06	1.04, 1.08

\*Final model includes 372 residents with complete data.

<sup>†</sup>High rate defined as  $\geq 90^{\text{th}}$  percentile for the state of Massachusetts (1277 cases/100,000 people), as reported by Massachusetts and Boston DPH as of May 6, 2020.

The community where staff lived was also a significant predictor of disease. A recent study of surveillance testing among more than 15,000 staff members from assisted living facilities and skilled nursing facilities found that 92.4% of staff who test positive for COVID-19 were asymptomatic at the time of testing.<sup>23</sup> Thus, staff members who reside in a community with a high burden of COVID-19 may inadvertently expose nursing home residents. Two recent studies are consistent with our findings: the strongest factors associated with COVID-19 outbreaks in nursing home facilities was larger facility size and geography.<sup>24,25</sup> To put our findings in context, in a facility with 50 direct care staff, for every 5 staff members who live in a community with a high burden of COVID-19, each resident's risk of contracting COVID-19 increases by 6%. Rates of COVID-19 in the communities where staff resided reflect a broad prevalence comparable to Massachusetts state data (Supplementary Table 1), and it is unlikely that single zip code outliers were responsible for our results. Together, these findings suggest that community prevalence of COVID-19 remains a major risk factor for nursing home outbreaks, and thus efforts directed toward mitigating outbreaks in nursing homes must additionally consider the broader community which they belong to.

There are weaknesses of our study. First, data on clinical characteristics was collected from retrospective chart review, and we suspect underreporting of some symptoms. Second, we did not have comprehensive staff testing during the study dates to directly determine COVID-19 status. We chose to collect zip code information on nurses and personal care attendants as the largest group of employees with direct patient contact. It is possible that some staff members had exposures apart from their local communities. Third, during the beginning of our study period, nurses and care attendants rarely worked on multiple units; however, during the later weeks of the study, staff illness necessitated some movement between units. This was kept to a minimum, and as most of our cases took place in the earlier half of the study, it was less likely to influence results. Fourth, our model to predict COVID-19 disease aggregated staff exposure at the level of the unit. The third and fourth limitation may result in some misclassification of staff residence. This should bias our results to the null, so the true association between staff residence and COVID-19 infection may be higher. Finally, our results are from a single, academic facility. Our patient population is older and has a greater burden of comorbidities than most community nursing homes. The overall census of our facility is equivalent to several nursing homes. Although resident characteristics differ across units, staffing is independent on each unit and infection control and admission policies are standardized across all units. Thus, our finding of differential infection prevalence across units strongly suggests that other nursing home residents who require a high level of care and live in a community with a high burden of COVID-19 are vulnerable.

## Conclusions and Implications

First, given the large number of asymptomatic carriers, universal testing of long-term care residents is strongly recommended. Second, standardized quick assessments for delirium may be useful in identifying early cases of COVID-19. Third, special attention should be given to residents with bowel incontinence, as the close, direct contact required to care for these residents may confer particularly high risk for the virus. Finally, because the community where staff live was a significant predictor of COVID-19 disease, early testing of direct patient care staff is recommended. As part of early response to the pandemic some cities and health systems offered alternative housing for healthcare workers. Allowing nursing home care workers to take advantage of such opportunities may be a strategy to reduce community exposure and potential introduction into the facility. Lastly, many states are now recommending universal testing of all nursing home workers, who provide direct patient care. Facilities with limited resources could consider prioritizing testing for staff in neighborhoods where COVID-19 is most prevalent.

In summary, despite the abundant precautionary measures initiated in a well-resourced long-term care facility, COVID-19 disease was prevalent in many of the long-term care units. More than 40% of infected residents were asymptomatic at the time of diagnosis, and many never developed symptoms. Male sex, bowel incontinence, and the community where staff lived were predictors of COVID-19 infection. Improved strategies to detect and mitigate spread of COVID-19 within long-term care facilities are urgently needed. We hope that our findings and implications will be informative as these strategies are being developed.

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**Supplementary Table 1**

Comparison of Aggregated State, Facility, and Unit Level COVID-19 Prevalence (Cases/100,000 Persons)

	Massachusetts State	Entire Facility	High Prevalence Unit	Low Prevalence Unit
Range	0–5958	171–5958	380–3236	171–2601
Quartile - 25th	293	1069	1355	700
Quartile - 50th	478	1732	1882	1053
Mean	642	1704	1811	1240
Quartile - 75th	856	2148	2162	1732

**Supplementary Table 2**

Presence of Symptoms at Any Time for Overall Cohort vs Those With Full 21 Days Follow-Up

	Total COVID-19 + Residents (n = 146) (%)	COVID-19 + with 21 d Follow-Up (n = 89) (%)	Prefrail FI < 0.25 (n = 22)	Mild Frailty FI 0.25–0.34 (n = 34)	Moderate to Severe Frailty FI ≥ 0.35 (n = 33)	P Value*
Days of Fever (mean ± SD)	1.8 ± 2.0	2.1 ± 2.1	2.4 ± 1.9	2.0 ± 2.2	2.1 ± 2.4	
Delirium	83 (57.6)	53 (60.2)	12 (54.6)	19 (55.9)	22 (68.8)	.46
Anorexia	102 (70.8)	68 (77.3)	19 (86.4)	25 (73.5)	24 (75.0)	.50
Fall	22 (15.1)	16 (18.0)	7 (31.8)	5 (14.7)	4 (12.1)	.14
Required Oxygen	58 (40.0)	37 (41.6)	9 (40.9)	11 (32.4)	17 (51.5)	.28
Hospitalization	9 (6.5)	4 (4.6)	1 (4.8)	1 (2.9)	2 (6.3)	.81
Death	44 (30.1)	31 (34.8)	5 (22.7)	9 (26.5)	17 (51.5)	.04

FI, frailty index; SD, standard deviation.

\*P value testing  $\chi^2$  difference by frailty status.